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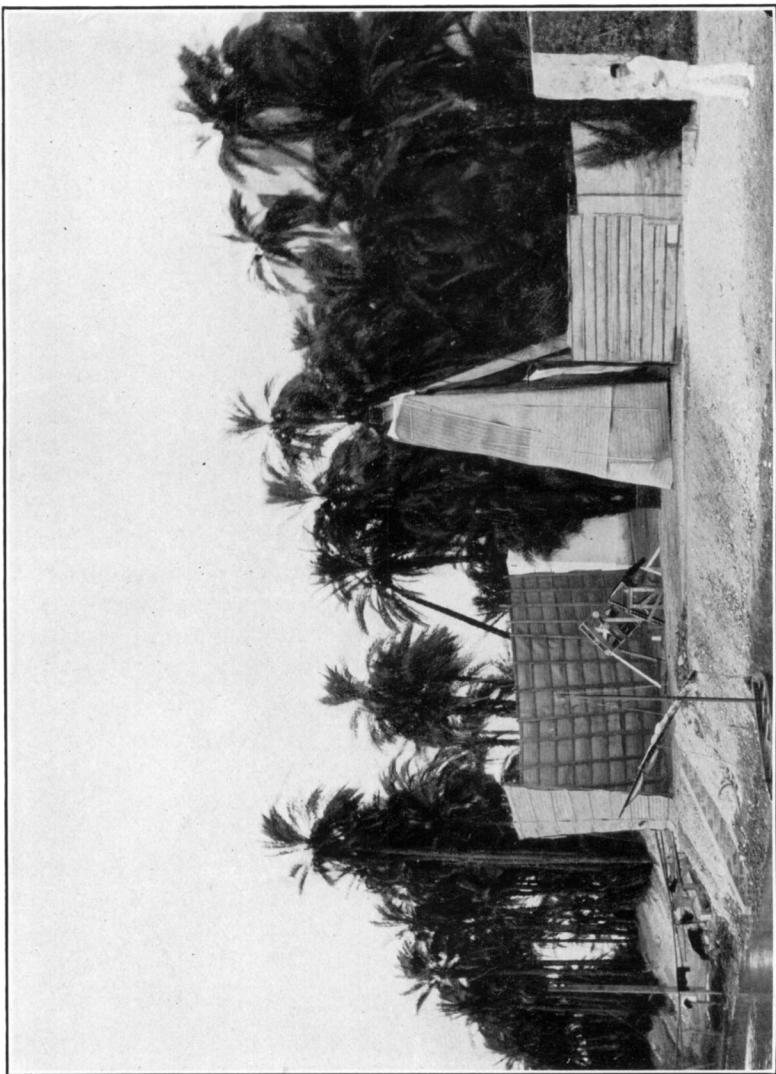
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LICK OBSERVATORY-CROCKER ECLIPSE STATION AT ELEPHANTINE ISLAND, ASWAN, EGYPT.

THE LICK OBSERVATORY-CROCKER ECLIPSE
EXPEDITION TO EGYPT.

By W. J. HUSSEY.

To be charged with the conduct of an eclipse expedition is a duty always prized by the astronomer, not only for the opportunity it gives to see and study a rare and beautiful phenomenon, but also for the advantages which come from voyages to far parts of the Earth, the experience of new and varied conditions, and the meeting with others who likewise journey to an unique errand. It therefore afforded me great pleasure to be intrusted with the expedition sent out by the Lick Observatory to Egypt, a country full of interest in and for itself, and with a background of history the most remarkable known to the world.

Accompanied by Mrs. HUSSEY, I left California early in June for a short holiday season in Switzerland and Italy. The equipment for the Egyptian expedition was brought later with that of the expedition to Spain, by Professor PERRINE, from New York to Naples, where I met him on the arrival of the steamship "Romanic," on the 19th of July. The Egyptian freight was transferred by lighter to the custom-house, where it remained for a week in bond, until the next sailing for Alexandria.

A distinctive endeavor of the Lick Observatory at the recent eclipse was, in addition to an extensive programme of photographic, spectrographic, and polarigraphic work to be carried on at the central station in Spain, to secure comparative data respecting coronal changes and possible intramericurial planets by the establishment of terminal stations in Egypt and the Labrador. This fact gave triple interest to our undertaking, keeping constantly in mind the thought of our colleagues at the other stations, and especially the contrast between our conditions on the tropical borders with those of the Labrador under the Arctic Circle. There were no icebergs to skirt our path as our fruit-laden ship steamed through the Strait of Messina and down the blue Mediterranean, four days to the south from Naples. No snow lay in gullies, nor heavy

mists hid the headlands when we again sighted land. The yellow shores of Africa stretched long and low in the face of a cloudless dawn. The yellow bluffs at the right were penciled with thin palms, erect, campanulate, like the wands that Cleopatra's women held before her when, in these very waters, she came down to meet the Roman galleys. But the lantern of the Pharos on the left, far less kin to the ancient world, brought us sharply back to the present day and the modern city of Alexandria before us, Oriental only in its thronging street-life and in all the costumes and colors of the East.

The floating dock was adjusted by brown men in baggy trousers and various headgears, whose contrasting features betrayed a dozen different tribes or nationalities. Scarcely was the ship moored when there appeared on the deck two Englishmen, who came to us as directly as old acquaintances, Captain H. G. LYONS, R. E., Director-General of the Survey Department, Egypt, and one of his Inspectors, Mr. B. F. E. KEELING, now the Acting Director of the Helwan Observatory. Thereupon began the pleasantest experience of being "personally conducted" we have known, an experience lasting to the day of our leaving this delightful land. The numberless courtesies afforded us by Captain LYONS and his staff were, he assured us, "by order of the Egyptian Government." Certainly we wish that the powers responsible might know how thoroughly all the visiting expeditions appreciated the favors of which they were the recipients during their stay in the country of the Nile.

In Cairo we passed some days, during which Professor TURNER arrived from Oxford, and later Mr. BELLAMY with the British expedition freight. Our colleague-to-be, Professor ROBERT H. WEST, of the Syrian Protestant College at Beirut, here joined us, and we perfected our plans and arrangements for the station work at Aswan. The American expedition was favored with some delightful courtesies, notably from Mr. FREDERICK GRINNELL MORGAN, Consul-Gerant of the United States, and from the Bureau of Antiquities, the Railway Administration, and various members of the Survey Department staff. We were taken by Government launch to the great Delta and Aswan Barrages, and in seeing the Pyramids

and the most interesting points in and about Cairo, at Luxor and Aswan, were never left to the mercy of the dragoman. Professor WEST, as well as Captain LYONS and his engineers, spoke Arabic fluently, with the result that our impression of the Egyptians throughout our stay was of quite a different nature from that of the ordinary traveler.

Three expeditions, Russian, British, and American, were expected to arrive in Cairo during the first week of August, and Captain LYONS had arranged that all should go together by the through train of the evening of Monday, the 7th, arriving at Aswan the following afternoon. The Russians, however, were delayed, and leaving Mr. DICKINSON to meet and escort them later, Captain LYONS, with Mr. KEELING, accompanied the others as planned. The train which awaited us was well equipped, and the night passed in comfort, with only the regret that in our rapid travel we were missing the sight of the vastly interesting country of the Lower Nile Basin. In the morning we passed Sohag, reminiscent of the eclipse of 1882, when the first photographic comet was found on the plates obtained by the British expedition.

Our journey was hot and dusty, of course, for this was Egypt and the month was August. But we had suffered worse in New York from humid heat, and on the Western plains from alkaline dust. However, our impressions here were not what they might have been but for Captain LYONS's thoughtfulness. He knew Upper Egypt and the "Soudan thirst." Therefore, we were especially supplied with fruit and drink for the last stages of the desert from Luxor. Here the railway changes from standard to narrow-gauge. The dining-car and the comfortable sleeper are left behind, and we have instead a queer-looking train of double-sided and double-roofed cars, those of the first class having two compartments, equipped with easy leather-bottomed chairs, movable, but ranged along the outer walls, facing each other. Half the car was assigned to our party, and, with our ice-boxes, provision-baskets, and pith helmets, we filled it, just.

All the afternoon we were thinking of the work ahead of us in the heat, the full force of which we were only now beginning to realize. The desert ran to the river's edge, shimmering in the sun, or melting back toward the distant cliffs into a

blue mirage of false lakes and lagoons. Interest grew as we approached Kom Ombo, where the edge of the eclipse shadow would pass. It was the height of the afternoon, and we went out to dicker with the Arabs for white grapes. A "bolis" (policeman) stood patron to each bargain, signaling the passenger what was fair and compelling the Arab to give full weight. We returned to the relief of the blue-windowed car, putting our grapes to cool in the ice-water.

Later came Khatara, where the Russian expedition expected to stop, as it was on the central line of the eclipse. We looked at the little sun-dried town and predicted that the Russians would follow us to Aswan, wondering meanwhile what we should find there. What we did find was a shining city,—dried mud and Arab shacks in the rear, to be sure, but two- and three-storied in front and white-painted by Kitchener's decree, with such a water-front as no other Upper Egyptian town can boast, though little they like him for it.

Directly in front of Aswan lies Elephantine, the long island at the foot of the First Cataract, with the Savoy Hotel conspicuous on its north point. Arrangements had been made by Captain LYONS for the accommodation of the several expeditions at this hotel, which is usually closed at this season. Thither we were at once transferred by sail-boats which were waiting just below the station. Here indeed was no Khatara, but a European hostelry, in pleasant gardens, past which the river swept on either side in strong current, for the time of flood was approaching.

Our first desire was to prospect for sites for our stations. In the sunset Captain LYONS, Professor TURNER, Professor WEST, and the writer took a brisk walk through the native villages and the dhurra-fields to the upper end of the island, where the remains of ancient Elephantine rise in mounds of stratified débris, formed as one century built upon the crumbling ruins of the preceding. Here there are Roman fragments, too, of TRAJAN's time. Perchance besides these very columns JUVENAL may have watched that Sun go down, reflecting upon the clever irony of his honorable exile. But no less to him than to us the Pharaohs were dead and Yebu forgotten, and the princes of Elephantine slumbered in their rock-hewn tombs.

As a result of our tour of inspection we came to the con-

clusion that the best sites for the eclipse stations were near the north end of the island in the hotel grounds. Permission was readily granted us to establish our stations within the gardens, and my choice fell at once upon a sandy strip of Nile bank adjacent to the west wing of the hotel. This site was shaded during much of the forenoon by a thicket of young palms, overtopped by old trees fifty or more feet in height, but afforded an unobstructed view toward the west, the low hills beyond the river rising only four degrees above the horizon. Moreover, the broad stretch of water between this place and the mainland in the direction of prevailing wind added greatly to our comfort by reducing the amount of wind-blown sand, and doubtless also somewhat alleviated the bad effect of radiation from the contiguous desert.

In the midst of the palm thicket, adjacent to our station, was a thick-walled mud house, empty in summer, but used in winter for the storage of meat. At the outset the hotel management placed this at our disposal for a workshop. In this room and in the shade of the trees we unpacked and assembled the instruments in comparative comfort, though the maximum temperature day after day during the first weeks of our stay ranged from 108° to 110° , and even touched 113° . The coolest rooms of the hotel rarely fell below 90° , and even at bedtime they were often above 100° . The air was so dry that this heat caused no lassitude. The sensation of having everything about warmer than one's self was novel and an ever-present argument against restlessness. When one had cooled the bed to his own temperature it was well to lie still in that spot. Out of doors late at night the thermometer might fall to the eighties, and to sleep on the roof or balconies has come to be the well-nigh universal custom.

The Egyptian sky is impressive as a spectacle, but, so far as my observations go, the seeing at this time of year is not of good quality. As might be expected the great heated areas, with rapid radiation, cause trembling images, which in a powerful instrument would seriously interfere with effective work. At no time, with the photographic tests, was I able to secure clear definition. Through the kindness of Captain LYONS, Mr. WADE sent to Aswan the eight-inch objective of the Helwan Observatory, in the hope that I might mount it

for visual tests. Other work, however, took my time to its exclusion.

Labor was cheap and abundant at Aswan. While our colleagues in the Labrador were finding it impossible, on account of the salmon run, to get a man at any price, we could have had any number at twenty-five cents a day. The custom of the country is to work through native overseers, and to our surprise we found that Captain LYONS had provided even for this need, and had brought four of those in the employ of the Survey Department on the same train with us from Cairo. One of these, MURSI, was assigned to the Lick Observatory camp, and the others to the English and Russian parties, for the Russians, as predicted, had promptly joined us at Elephantine. Through Mr. KEELING and MURSI, the selection of day and night watchmen, of laborers, and of contractors for building the necessary piers and an effective wind-screen were soon effected. The routine of the establishment of the eclipse apparatus progressed steadily, but without haste.

During the week preceding the eclipse, Mr. Joy, a graduate of Oberlin, and Mr. NELSON, an alumnus of the University of Chicago, joined the Lick Observatory expedition from Beirut. Captain LYONS returned to assist Professor TURNER with the Oxford expedition, but kept an active interest in us all, still seeing something to offer for our advantage or assistance. He secured us the added services of Messrs. TRIMAN, DRAY, and CURRY, of the Survey Department, in Cairo, and of Messrs. SWIFT and WILD, of the Ministry of Public Instruction.

During these last days we were all keenly interested in the arrival of Mr. REYNOLDS from Birmingham with a reflector of twenty-eight inches aperture and one hundred twenty feet focal length, and in the heroic effort to install it in time for the eclipse.

The 30th of August was absolutely clear, with a light wind, and a temperature of 108° in the afternoon. It was one of the most favorable days we had at Aswan, except that the sky was white with fine dust driven high in the air by a gale from the desert the day before. During the morning the equipment was critically examined. The plate-holders especially were inspected for any light leaks, additional thicknesses of black cloth were obtained to be placed before the tent door, and for

wrapping about the plate-holders when they were carried from the dark-room to the instruments. The entire spectroscope except the objective and a place to draw the slide was thickly wrapped in layer after layer of black cloth.

As the hour approached the plates were backed with a non-halation covering, placed in their holders, and wrapped thickly in black cloth. During the last moments of the partial phase these were carried from the dark-room to their respective instruments. The operators were in their places, alert for the signals of time, and ready each for his especial duty.

The exposures with the forty-foot camera were made by the writer, with Mr. DRAY, of Cairo, assisting. Professor WEST was given general charge of the programme in the open, with Mr. TRIMEN as time-counter, and Mr. Joy at the spectroscope. At the intramercurial apparatus were Messrs. SWIFT, WILD, CURRY, NELSON, and Mr. BRUCE J. GIFFEN, of the American Mission at Luxor. Mr. GODFREY, of Zagazig, who happened to be present and offered his services, was asked to watch for shadow-bands against the tent of the forty-foot telescope. Mrs. HUSSEY, with Mr. ARTHUR KNOWLES, of Cairo, and Mr. GEORGE CALLENDAR BRACKETT, of Brooklyn, New York, also observed the shadow-bands against the tower of the Savoy roof.

The programme at the instruments was carried through with automatic precision. Each operator performed his part to the second, and the work was so planned that every one had at some time during totality a period free for viewing the eclipse. The Sun was nearly in the west, at an altitude of twenty-four degrees, for the afternoon was well advanced, the total phase beginning at $4^{\text{h}}\ 33^{\text{m}}\ 34^{\text{s}}$ mean local time. The computed duration of totality was two minutes thirty-one seconds.

The corona was of the usual sun-spot maximum type. The south preceding streamer, however, was noticeably long, slender, and recurving. By reason of the light sky, the corona was less brilliant to the eye than it had been to those who had seen other eclipses in localities with rain-washed atmosphere. But in respect to the prominences, it would seem that nothing could have been more impressive.

Immediately after the total phase had passed, the plates

were taken to the dark-room and stored to await development. There was an hour of frank congratulation over the tea and shandygaff, but there was no disguising the weariness of the observers after the long day and the event to which all the company had been intensely keyed.

The hotel terrace in the evening, with its notable visitors from down the river, seemed quite gay to us who had so long possessed it exclusively, and the banquet given on the lawn below in the gardens by Mr. MITCHELL-INNES, Under-Secretary of State for Finance, to the eclipse expeditions, Captain LYONS, the Mudir of Aswan, and other guests, brought to a delightful ending our weeks of pleasant association.

Sunrise saw the departure of Mr. MITCHELL-INNES's steamer, with Captain LYONS aboard. The guests of the hotel went, most of them, by the morning train to Luxor. Many of the assistants remained to help dismount the instruments and straighten up the camps, and by evening of the 31st little remained to mark their sites. M. OCULVITCH and M. BAIKOFF packed their plates for development at St. Petersburg. Dr. MEYER, of Berlin, boxed his portable Zeiss altazimuth and departed for Italy. Mr. REYNOLDS and Mr. KEELING were off for Helwan, to install the thirty-inch reflector that Mr. REYNOLDS has presented to the Egyptian Government, and from which we hope to hear notable things in the near future. Professor TURNER and Mr. BELLAMY took the train to Cairo, carrying their plates to the spacious dark-rooms of the Survey Department for development. Professor WEST had sailed from Port Said for his mountain home in Syria, leaving us conscious of the loss of his resourcefulness, his congenial companionship, and his invaluable aid in all ways during our association at Aswan. In addition to his technical skill, his mastery of Arabic and his insight into Oriental character were no small factors in establishing the cordial relations with our native helpers, which continued to the end of our stay at Elephantine.

The company at the Savoy had now dwindled to ourselves, Mr. DICKINSON, and M. DUBINSKY, of Pawlowsk, who for nearly a fortnight longer continued his magnetic observations in the tomb of one of the ancient princes of Elephantine. He had here ideal rooms for his work, cut one beyond the other into the side of the hill of the Dome of the Winds, away from all

disturbing surface conditions, the range of temperature day after day amounting to less than a degree Fahrenheit.

The last ten days of our stay at Aswan proved the most trying that we had, for the winds dropped and the humidity rose above fifty. Operations in the dark-room were necessarily restricted to night and early morning, and the behavior of the chemicals in the heat and the uninterpreted action of other agencies added perplexities to the work of development. Our dark-rooms were improvised without sinks or running water. The hotel gave us the unlimited use of its filters, and the Survey Department sent up generous supplies of distilled water from Cairo, while the willing labor of our ABBAS and MOHAMMED furnished the Oriental equivalent of Yankee conveniences. Ice was an essential, of course, brought by train from Cairo daily.

Nineteen photographs were obtained, having exposures varying from half a second for the inner corona, to sixty-four seconds for the fainter outlying streamers. With the intra-mercurial apparatus the time of totality was divided as nearly as might be to obtain duplicate plates along the ecliptic in the vicinity of the Sun. The exposure with the spectrograph lasted throughout totality, except for a second or two at the beginning and end.

No detailed study of photographs is made at an eclipse camp. This requires the resources of measuring-engines, microscopes, comparison-plates, and other records. At the observing station the one object is to bring out all the detail the plates will yield and fix them against the chance of accident from light or chemical change. They are then packed in their original boxes, separated at their edges by strips of paper. These are then sealed in tin, and put in a strong wooden box, excelsior lined. This is then packed in one stronger still, and labeled, in this case in three languages, English, French, and Arabic, for shipment to Mt. Hamilton.

Eclipse successes and failures have always a stimulating effect. By the following of clues in the earnest endeavor to learn more of the many things that formerly could be studied only during the brief moments of totality the effective means of research have been greatly extended and have given us what may be called indirect eclipse results quantitatively more

numerous perhaps than those which have been obtained directly. Holding in mind the great practical importance of a more complete understanding of the Sun and the high probability of light being thrown upon its problems by observations that can at present be made only during the brief and long-separated total eclipses, it is apparent that every opportunity should be embraced to make the most of these occasions. It is to the credit of the Lick Observatory that it has played a conspicuous part in the observation of eclipses of the Sun, and not too much can be said in commendation of the systematic giving by which Mr. WILLIAM H. CROCKER, and, before him, the late Colonel CHARLES F. CROCKER, have made possible the continuous study and investigation of these phenomena by that institution.

DETROIT OBSERVATORY, UNIVERSITY OF MICHIGAN,
ANN ARBOR, January 22, 1906.

NOTE ON ANOMALOUS REFRACTION.

By FRANK SCHLESINGER AND G. B. BLAIR.

Under normal conditions atmospheric strata of uniform density lie parallel to the Earth's surface. In this case the expression for refraction takes the well-known form $k \tan z$, in which z is the true zenith-distance of the object and k is a quantity that varies slowly with the zenith-distance, the temperature, and the height of the barometer. For present purposes, however, we may regard k as a constant and equal to $57''$.

Let us now consider the effect upon the refraction of a small inclination in the strata of uniform density. Imagine a normal to be drawn to these strata, and let ζ and a be respectively the zenith-distance and azimuth of the point at which this normal pierces the celestial sphere. This point is evidently the origin from which zenith-distances should be reckoned for the computation of the refraction under the assumed conditions. Consequently for z in the above formula